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# STRUCTURAL DESIGN STABILITY CERTIFICATE

I hereby certify that the Proposed Construction of Stilt + 5 Floors residential building with 125 dwelling units at Kundrathur Main Road, Moondramkattalai, comprised in Survey Nos. 12/2B & 12/2C, Moondramkattalai Village, Kundrathur Taluk, Kancheepuram District, will be constructed as per our Structural Design and detailed with structure members as provided in our drawing from foundation to Roof Slab.

The External and Internal walls are combination of 230/115mm thick AAC block Walls. Pile foundation is adopted for this Structure. The building is also designed for Seismic Zone III as per IS 1893 (Part-I)-2016. The loading stress parameters are within limits of National Building Code and Bureau of Indian Standards Practice for Concreting and loading.

I hereby certify that the Structure is sound and safe for the considered loading pattern and the type of usage.

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# DESIGN BASIS REPORT

# FOR

# RESIDENTIAL APPARTMENT (STILT+5 FLOORS)

# AT SURVEY NO. 12/2B & 12/2C, MOONDRAMKATTALAI VILLAGE, KUNDRATHUR TALUK, KANCHEEPURAM DISTRICT

**MP CONSULTANTS**

**ARCHITECTS AND STRUCTURAL CONSULTANTS**

mp developers

**MAY –2024**

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## 1. DESIGN ASSUMPTION

### a) STRUCTURAL SYSTEM

The structural system for the "PROPOSED **RESIDENTIAL APPARTMENT at survey No. 12/2B & 12/2C, Moondramkattalai village, Kundrathur Taluk, Kancheepuram District.",** consists of Stilt + 5 upper floors and OHT. The total height of the building is about 18 meter from Stilt floor level. The building designed for 9" & 4.5" thick AAC blocks. The structure is supported on Pile foundation below basement level as per the soil test report recommendation.

## 2. DESIGN LOADS

### a) Dead Load:

Dead Load considered on slab: Self Weight + 1.5 kN/m$^2$ for Floor Finish.

| | |
|---|---|
| Wall load | = 6 kN/m (230mm thick) |
| Wall load | = 3 kN/m (115mm thick) |
| Wall load (Parapet) | = 4 kN/m (115mm thick) |
| Staircase load | = 15 kN/m (RCC staircase) (LL+DL) |
| Sunken load | = 4kN/m$^2$ |
| Water Tank | = 15kN/m$^2$ (1500 mm height) |
| Floor finish | = 2kN/m$^2$ (Terrace) |

### b) Roof Live Load:

The super imposed load or otherwise live load is assessed based on the occupancy classifications as per IS = 0.75 kN/m$^2$ on Solar panel roof.

| | |
|---|---|
| Live Load considered on slab | =2 kN/m$^2$ |
| Live Load considered on slab | =3 kN/m$^2$ (Lobby & Staircase) |
| Live Load considered on slab | =1.5 kN/m$^2$ (Terrace) |

## 3. EARTHQUAKE LOAD

The loading due to earthquake is assessed based on the provisions of IS: 1893(Part-1):2016

| | |
|---|---|
| Seismic Zone | = III |
| Table-2 Zone factor (Z) | = 0.16 |
| Table-6 Importance Factor (I) | = 1.2 |
| Table-7 Response Reduction Factor (R) | = 5 |

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**Building frame system (SMRF) as per table 7 clause 6.4.2 of IS 1893 2016**

Height of building (H) =18m

Base dimension of part of the building along the considered direction of lateral force (D)

**Fundamental Natural time period**

$T_s$ = **$0.09H/\sqrt{d}$** from CL - 7.6.2 - IS 1893 (Part-I) 2016

$S_a/g$ = from FIG-2 IS 1893 (part-I) 2016

The respective natural time period can be referred from the respective model.

**Horizontal Seismic Co-efficient**

Ah = $(Z/2) \times (I/R) \times (S_a/g)$

**Seismic Base Shear**

Vb = Ah x W

Structure with ductile detailing is considered as per IS: 13920-2016

As per IS: 1893 – 2016, percentage of imposed loads to be considered for seismic weight calculation is mentioned below:

| **Imposed Uniformity Distributed Floor Load Loads ( kN/ m2)** | **Percentage of Imposed** |
|---|---|
| Up to & including 3.0 | 25 |
| Above 3.0 | 50 |

## 4. LOAD COMBINATIONS

**Strength combinations:**

- 1.5DL + 1.5 LL
- 1.5DL (+/-)1.5 WL/EQ Load
- 1.2DL +1.2LL (+/-) 1.5 WL/EQ Load
- 0.9DL (+/-) 1.5 WL/EQ Load

**Serviceability combinations:**

- DL + LL
- DL +0.8 LL(+/-) 0.8 WL/EQ Load
- DL (+/-) WL/EQ Load

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## 5. ANALYSIS METHOD

The structure is analyzed by static for gravity due to Earthquake loads and its combinations.

## 6. DESIGN METHODOLOGY

All structures have been designed according to the Limit State Method as specified in IS: 456-2000 & IS 1893 - 2016. Appropriate loads and its combinations, as per relevant clauses in IS 456:2000 code, for the most unfavorable effects are chosen for design.

## 7. MATERIALS

The self-weight of the various elements is computed based on the built weight of materials as given below: -

| Materials | Unit weight in kN/m$^3$ |
|---|---|
| Steel | 78.5 |
| Plain concrete | 24 |
| Reinforced concrete | 25 |
| Soil | 18 |
| AAC BLOCKS | 7 |

## 8. CONCRETE

All the concrete items for the construction have the following characteristics

Grade of Concrete = M25

Aggregate = 20mm and down size, mechanically crushed Aggregate.

## 9. STEEL

Steel reinforcement shall be of Grade Fe500 & Fe550 conforming to IS: 1786-2008.

## 10. COVER TO REINFORCEMENT

The clear cover to main reinforcement shall be as follows.

| | |
|---|---|
| Foundation | = PILE: 50mm, PILE CAP: 75mm |
| Slab | = 20mm |
| Columns | = 40mm |
| Beams | = 25m |

## 11. FOUNDATION SYSTEM

Foundation systems are based on recommendations given as per soil investigation report by BOOSHNAM ASSOCIATES.

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## 12. CODES & STANDARDS

All the design are conforming to the relevant Indian Standards. Some of the relevant Indian Standard Codes, which have been followed for the structural design are given below.

| | Description |
|---|---|
| IS:875 (Part-1)-1987 | Code of Practice for Design Loads (Other than Earthquake) for Building and Structures-Unit Weights of Buildings Materials and Stored Material. |
| IS:875 (Part-2)-1987 | Code of Practice for Design Loads (Other than Earthquake) for Building and Structures-Imposed loads |
| IS:875 (Part-3)-2015 | Code of Practice for Design Loads (Other than Earthquake) for Buildings and Structures –Wind Load. |
| IS:456 (Part-1)-2000 | Code of Practice for Plain and Reinforced Concrete |
| IS:1893 (Part-1)-2016 | Indian Standard Criteria for Earthquake Resistant Design of Structures. |
| IS:432 (Part-2)-1982 | Specification of Mild Steel and Medium Tensile Steel bars and Hard drawn Steel Wire for concrete reinforcement – Hard drawn Steel Wire. |
| IS:1786-2008 | Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement |
| IS:1904 | Indian Standard Code of practice for Design & Construction foundations in Soil: General Requirements. |
| IS:1642-1989 | Indian Standard Code of practice for Fire Safety Of Buildings (General): Details Of Construction. |

IS: 1786-2008 Specification for High Strength Deformed Steel Bars and Wires for Concrete Reinforcement. IS: 1904 Indian Standard Code of practice for Design & Construction foundations in Soil: General Requirements IS: 1642-1989 Indian Standard Code of practice for Fire Safety of buildings (General): Details of Construction.

## 13. STRUCTURAL ANALYSIS

The Building structures are analyzed using STAAD for various load combination as per Indian Codes.

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| PROJECT NO | Residential building (stilt+5) BLOCK-3 | DOC.NO / GRID | SLAB DESIGN | | |
|---|---|---|---|---|---|
| TITLE | SLAB DESIGN -One way slab 3.40 x 6.85.0 M | 58/63 TO J/Q | S5 | | |

**ONE WAY SLAB**

**INPUT DATA:**

Shorter dimension of slab , $l_x$ = 3.40 m

Longer dimension of slab , $l_y$ = 6.85 m

$l_y / l_x$ = 2.01 One way slab

Characteric strength of concrete , $f_{ck}$ = 25 N/mm$^2$

Characteric strength of steel , $f_y$ = 500 N/mm$^2$

Diameter of bar used, $\phi$ = 10 mm

Clear cover = 20 mm

Width of slab, b = 1000 mm

Thickness of slab, D = 125 mm

Effective depth, d = 125-20-10/2
= 100 mm

**LOAD CALCULATION:**

Dead Load = 0.125*25 = 3.13 kN/m$^2$

Live Load = 2 kN/m$^2$

Floor Finish = 1.5 kN/m$^2$

Total Load W = 3.125+2+1.5 = 6.63 kN/m$^2$

Factored Load $W_u$ = 1.5*6.625 = 9.94 kN/m$^2$

**MOMENT CALCULATION:**

Maximum Bending Moment $M_u$ = $W_u * l_x^2 / 8$ = 9.94*3.4*3.4/8

$M_u$ = 14.4 kNm

**MAIN REINFORCEMENT:**

$M_u/bd^2$ = 14.36*10^6/(1000*100*100

= 1.44 N/mm$^2$

$Pt_{req}$ = 0.367 % (From SP-16, Table-3)

$Ast_{req}$ = 0.367*1000*100/100

= 367 mm$^2$

Provide 10 mm bar @ 150 C/C

$Ast_{prov}$ = 1000*3.14*10*10/4*150

= 523 mm$^2$

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**DISTRIBUTION REINFORCEMENT:**

$(Ast_{min})_{req}$ = 0.0012*1000*125

= 150 $mm^2$

Provide 8 mm bar @ 200 C/C

$(Ast_{min})_{pro}$ = 1000*3.14*8*8/4*200

= 251 $mm^2$

**CHECK FOR SHEAR:**

Actual shear load $V_u$ = $W_u$*$l_x$ / 2 = 9.94*3.4/2

= 16.9 kN

Actual shear stress $V_u/bd$ = 16.9*10^3/(1000*100

$\zeta v$ = 0.17 $N/mm^2$

Percentage of tension reft prov, $Pt_{prov}$ = 100*523/100*1000

= 0.52 %

IS:456-2000 Table-19
Allowable shear stress $\zeta c$ = 0.5 $N/mm^2$

As per IS:456,cl:40.2.1.1
k value for slab = 1.3

Design shear stress for concrete = k x $\zeta c$ = 1.3*0.497

= 0.65 $N/mm^2$

Actual shear stress < Design shear stress
Hence safe

**CHECK FOR DEFLECTION:**

Type of slab = Continuous

Allowable span / depth ratio l/d = 26

Steel stress of service load, $f_s$ = 0.58*$f_y$*(Area of steel required/Area of steel provided)

= 204 $N/mm^2$

Percentage of comp. reinforcement = 0.25 % (Minimum rft)

Percentage of tension reft prov, $Pt_{prov}$ = 0.52 %

M. factor for tension rft, F1 = 1.42 (From fig:4 ,IS:456-2000)

M. factor for comp. rft, F2 = 1 (From fig:5 ,IS:456-2000)

Modified span/depth ratio = l/d x F1x F2 = 26*1.42*1

= 36.9

Actual span/ depth ratio = $l_x$ /d = 3.4*1000/100

= 34

Actual span/ depth ratio < Modified span / depth ratio
Hence safe

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BEAM DESIGN

| | | | |
|---|---|---|---|
| Grid | | : **(K'/P'-71)** | |
| Beam No | | : **B204 (9"X 15")** | |
| Analysis Reference (Member) | 8 m | : 931 | |
| Beam Length | | : 3200 | mm |
| Breadth (B) | | : 230 | mm |
| Depth (D) | | : 380 | mm |
| Effective Depth (d) | | : 345 | mm |
| Design Code | | : IS 456 | |
| Beam Type | | : Regular Beam | |
| Grade Of Concrete (Fck) | | : M25 | N/sqmm |
| Grade Of Steel | | : Fe550 | N/sqmm |
| Clear Cover (Cmin) | | : 25 | mm |
| Es | | : 2x10^5 | N/sqmm |

| **Flexure Design** | | | | | | |
|---|---|---|---|---|---|---|
| | **Beam Bottom** | | | **Beam Top** | | |
| | **Left** | **Mid** | **Right** | **Left** | **Mid** | **Right** |
| Critical L/C - Analysis | 504 | 404 | 504 | 401 | 501 | 401 |
| Critical L/C - RCDC | 38 | 30 | 38 | 27 | 35 | 27 |
| Mu (kNm) | 85.36 | 59.03 | 63.3 | 93.6 | 46.16 | 88.5 |
| Tu (kNm) | 2.34 | 1.99 | 2.34 | 3.74 | 3.39 | 3.74 |
| $M_{Tu}$ (kNm) | 3.65 | 3.11 | 3.65 | 5.83 | 5.29 | 5.83 |
| Mud (kNm) | 89.01 | 62.14 | 66.96 | 111.22 | 51.45 | 99.43 |
| MuLim (kNm) | 89 | 89 | 89 | 89 | 89 | 89 |
| R | 3.252 | 2.27 | 2.446 | 4.063 | 1.879 | 3.632 |
| Ptmin (%) | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 | 0.2 |
| Ptclc (%) | 0.833 | 0.538 | 0.587 | 1.022 | 0.435 | 0.922 |
| Pcclc (%) | 0 | 0 | 0 | 0.209 | 0 | 0.098 |
| PtPrv (%) | 1.237 | 1.237 | 1.237 | 1.237 | 1.237 | 1.237 |
| AstCalc (sqmm) | 660.93 | 427.28 | 466.13 | 714 | 344.8 | 700 |
| AstPrv (sqmm) | 716 | 716 | 716 | 716 | 716 | 716 |
| Reinforcement Provided | 2-T16 + 1Y20 | 2-T16 + 1Y20 | 2-T16 + 1Y20 | 2-T16 + 1Y20 | 2-T16 + 1Y20 | 2-T16 + 1Y20 |

| **Shear Design** | | | |
|---|---|---|---|
| | **Left** | **Mid** | **Right** |
| Critical L/C - Analysis | 401 | 401 | 404 |
| Critical L/C - RCDC | 27 | 27 | 30 |
| PtPrv (%) | 0.95 | 0.95 | 0.95 |
| Vu (kN) | 83.31 | 64.93 | 87.32 |

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| | | | |
|---|---|---|---|
| Tu (kNm) | 3.74 | 3.74 | 1.99 |
| $V_{Tu}$ (kN) | 26.01 | 26.01 | 13.86 |
| Vut (kN) | 109.32 | 90.94 | 101.18 |
| Tv (N/sqmm) | 1.38 | 1.15 | 1.28 |
| Tc (N/sqmm) | 0.69 | 0.69 | 0.69 |
| Vc (kN) | 55.03 | 55.03 | 55.03 |
| Vus=Vut-Vc (kN) | 54.29 | 35.91 | 46.15 |
| Legs | 2 | 2 | 2 |
| Stirrup Rebar | 8 | 8 | 8 |
| Asv Torsion (sqmm) | 521.67 | 454.917 | 433.894 |
| Asv Torsion Prv (sqmm) | 773.38 | 773.38 | 773.38 |
| Asv Reqd (sqmm/m) | 435.87 | 288.33 | 370.51 |
| SvCalc (mm) | 130 | 130 | 130 |
| SvPrv (mm) | 130 | 130 | 130 |
| Asv Total Prv (sqmm) | 773.38 | 773.38 | 773.38 |

**Maximum Spacing Criteria**

Basic

Spc1 =0.75d = 259 mm

Spc2 = 300 mm

For Torsion

(X1 = 190, Y1 = 340)

Spc3 = X1 = 190 mm

Spc4=(X1+Y1)/4 = 130 mm

**SFR Design**

Beam Width = 230 mm

Beam Depth = 380 mm

Web Depth = 380 <= 750 mm

Side Face Reinforcement not required.

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## COLUMN DESIGN

### General Data

| | | | |
|---|---|---|---|
| Column No. | : | **C13 &GRID (73/H)** | |
| Level | : | **FIRST TO SECOND FLOOR COLUMN** | |
| Frame Type | = | Ductile | |
| Response Reduction Factor | = | 5 | |
| Design Code | = | IS 456 + IS 13920 - 2016 | |
| Grade Of Concrete | = | M25 | N/sqmm |
| Grade Of Steel | = | Fe550 | N/sqmm |
| Column B | = | 230 | mm |
| Column D | = | 450 | mm |
| Clear Cover | = | 40 | mm |
| Clear Floor Height @ B | = | 2550 | mm |
| Clear Floor Height @ D | = | 2550 | mm |
| No Of Floors | = | 1 | |
| No Of Columns In Group | = | 1 | |
| Column Type | : | Braced | |
| Minimum eccentricity check | : | Simultaneously (Both Axis) | |
| Code defined D/B ratio | : | 4 | |
| D/B Ratio | : | 1.96 <= 4 Hence, Design as Column | |

### Flexural Design (Analysis Forces)

| | | | |
|---|---|---|---|
| Analysis Reference No. | = | 191 | |
| Critical Analysis Load Combination | : | 405 | |
| Load Combination | = | [31] : 1.5 (LOAD 3: DL) +0.45 (LOAD 1: RSX) +1.5 (LOAD 2: RSZ) | |
| Critical Location | = | Bottom Joint | |
| Put (top joint) | = | 1191.58 | kN |
| Muxt (top joint) | = | 49.82 | kNm |
| Muyt (top joint) | = | 34.28 | kNm |
| Vuxt (top joint) | = | 23.38 | kN |
| Vuyt (top joint) | = | 96.05 | kN |
| Pub (bottom joint) | = | 1203.23 | kN |
| Muxb (bottom joint) | = | 150.11 | kNm |
| Muyb (bottom joint) | = | 30.96 | kNm |
| Vuxb (bottom joint) | = | 23.38 | kN |
| Vuyb (bottom joint) | = | 96.05 | kN |

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## Effective Length Calculation

### Calculation Along Major Axis Of Column

| Joint | Column Stiffness | Beam Sizes | | Beam Stiffness | | Beta |
|---|---|---|---|---|---|---|
| | | Beam 1 (Length x Width x Depth) | Beam 2 (Length x Width x Depth) | Beam 1 | Beam 2 | |
| | N-m x 10^6 | mm | mm | N-m x 10^6 | N-m x 10^6 | |
| Bottom | 116.438 | No Beam | No Beam | - | - | 0.875 |
| Top | 116.438 | 3600 x 230 x 450 | 5380 x 230 x 600 | 48.516 | 76.952 | 0.65 |

| | | |
|---|---|---|
| Sway Condition (as per Stability Index) | = | Non Sway |
| Effective Length Factor along Major Axis | = | 0.83 |

### Calculation Along Minor Axis Of Column

| Joint | Column Stiffness | Beam Sizes | | Beam Stiffness | | Beta |
|---|---|---|---|---|---|---|
| | | Beam 1 (Length x Width x Depth) | Beam 2 (Length x Width x Depth) | Beam 1 | Beam 2 | |
| | N-m x 10^6 | mm | mm | N-m x 10^6 | N-m x 10^6 | |
| Bottom | 30.418 | No Beam | No Beam | - | - | 0.874 |
| Top | 30.418 | 3300 x 230 x 450 | No Beam | 52.926 | - | 0.535 |

| | | |
|---|---|---|
| Sway Condition (as per Stability Index) | = | Sway |
| Effective Length Factor along Minor axis | = | 2.08 |

## Minimum Eccentricity Check

Since Axial Force is compressive, Min. Eccentricity check to be performed

Minimum Eccentricity Along D:

| | | | |
|---|---|---|---|
| Minimum Eccentricity | = | Unsupported Length / 500 + D / 30 | |
| | = | 20.1 | mm |
| Minimum Eccentricity | > | 20 | mm |
| Mminx (top) | = | Pu x Minimum Eccentricity | |
| | = | 23.95 | kNm |
| Mminx (bottom) | = | Pu x Minimum Eccentricity | |
| | = | 24.18 | kNm |

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Minimum Eccentricity Along B :

| | | | |
|---|---|---|---|
| Minimum Eccentricity | = | Unsupported Length / 500 + B / 30 | |
| | = | 12.77 | mm |
| Minimum Eccentricity | > | 20 | mm |
| MminY (top) | = | Pu x Minimum Eccentricity | |
| | = | 23.83 | kNm |
| MminY (bottom) | = | Pu x Minimum Eccentricity | |
| | = | 24.06 | kNm |

**Slenderness Check**

| | | | |
|---|---|---|---|
| Max Slenderness Ratio(L/B) | = | 11.09 | |
| | < | 60 | (Hence Ok) |
| Column Is Braced Along D | | | |
| Slenderness Check Along D: | | | |
| Effective Length Factor | = | 0.83 | |
| Slenderness Ratio | = | Effective Length / D | |
| | = | 4.7, Column not Slender Along D | |
| Column Is Braced Along B | | | |
| Slenderness Check Along B: | | | |
| Effective Length Factor | = | 2.08 | |
| Slenderness Ratio | = | Effective Length / B | |
| | = | 23.06, Column Slender Along B | |
| Slenderness moment along B | = | (Pu B/ 2000) (Ley/B)^2 | |
| | = | 72.87 | kNm |

Design slenderness moment along B

| | | | |
|---|---|---|---|
| Puz | = | 2740.07 | kN |
| Pb | = | 404.38 | kN |
| Reduction factor 'k' for slenderness moment | = | (Puz - Pu) / (Puz - Pb) < = 1 | |
| | = | 0.66 < = 1, Hence k=0.66 | |
| Mslndy | = | k x 72.87 | |
| | = | 48.31 | kNm |

**Calculation of Design Moment**

| Direction | Manalysis | Mmin (Abs) | Mdesign | Minit | Mslndx (Abs) | Mdesign-final |
|---|---|---|---|---|---|---|
| | A | B | C | D | E | F |
| Major Axis Mux (top) | 49.82 | 23.95 | 49.82 | --- | 0 | 49.82 |
| Major Axis Mux (bottom) | 150.11 | 24.18 | 150.11 | --- | 0 | 150.11 |
| Minor Axis Muy (top) | 34.28 | 23.83 | 34.28 | 8.18 | 48.31 | 62.03 |
| Minor Axis Muy (bottom) | 30.96 | 24.06 | 30.96 | 8.18 | 48.42 | 62.13 |

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**Where**

| | | |
|---|---|---|
| A | = | Moments directly from analysis |
| B | = | Moments due to minimum eccentricity |
| C | = | Maximum of analysis moment and min. eccentricity = Max (A,B) |
| D | = | Initial moment = 0.4 x Min (top, bottom) ± 0.6 x Max (top, bottom) [As per sign requirement] |
| E | = | Moment due to slenderness effect |
| F | = | Final design Moment = Max(C- Top Bottom , D- Top Bottom) + E |

**Final Critical Design Forces**

| | | | |
|---|---|---|---|
| Pu | = | 1203.23 | kN |
| Mux | = | 150.11 | kNm |
| Muy | = | 62.13 | kNm |

**Resultant Moment (Combined Action)**

**Moment Capacity Check**

| | | | |
|---|---|---|---|
| Pt Calculated | = | 3.79 | |
| Reinforcement Provided | = | 6-T25 + 4 -T20 | |
| Load Angle | = | $Tan^{-1}$(Muy/Mux) | |
| | = | 22.48 | deg |
| MRes | = | 162.46 | kNm |
| MCap | = | 163.89 | kNm |
| Capacity Ratio | = | MRes/ MCap | |
| | = | 0.92 <= 1 | |

**Shear Design (Analysis Forces)**

**Design for shear along D**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | : | 405 | |
| Critical Load Combination | = | [31] : 1.5 (LOAD 3: DL) +0.45 (LOAD 1: RSX) +1.5 (LOAD 2: RSZ) | |
| Design shear force, Vuy | = | 96.0452 | kN |
| Pu | = | 1191.58 | kN |
| Deff | = | 397.5 | mm |
| Design shear stress, Tvy | = | Vuy / (Bx Deff) | N/sqmm |

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| | | | |
|---|---|---|---|
| | = | 1.0505 | N/sqmm |
| Pt | = | 1.897 | % |
| Design shear strength, Tc | = | 0.8038 | N/sqmm |
| Shear Strength Enhancement Factor | = | 1 + 3 x Pu / ( B x D x Fck) | |
| | = | 2.3815 | |
| Shear Strength Enhancement Factor (max) | = | 1.5 | |
| Shear Strength Enhancement Factor | = | 1.5 | |
| Enhanced shear strength, Tc-e | = | 1.2056 | N/sqmm |
| Design shear check | = | Tvy < Tc x Enhancement factor | |
| **Link for Shear Design along D are not required** | | | |

**Design for shear along B**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | : | 401 | |
| Critical Load Combination | = | [27] : 1.5 (LOAD 3: DL) +1.5 (LOAD 1: RSX) +0.45 (LOAD 2: RSZ) | |
| Design shear force, Vux | = | 30.695 | kN |
| Pu | = | 1215.2 | kN |
| Beff | = | 177.5 | mm |
| Design shear stress, Tvx | = | Vux / (D x Beff) | kN |
| | = | 0.3843 | N/sqmm |
| Pt | = | 1.897 | % |
| Design shear strength, Tc | = | 0.8038 | N/sqmm |
| Shear Strength Enhancement Factor | = | 1 + 3 x Pu / (B x D x Fck) | |
| | = | 2.4089 | |
| Shear Strength Enhancement Factor (max) | = | 1.5 | |
| Shear Strength Enhancement Factor | = | 1.5 | |
| Enhanced shear strength, Tc-e | = | 1.2056 | N/sqmm |
| Design shear check | = | Tvx < Tc x Enhancement factor | |
| **Link for Shear Design along B are not required** | | | |

**Design Of Links**

Links in the zone where special confining links are not required

Normal Links

Diameter of link = 8 mm

> Max. longitudinal bar dia / 4

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| | | |
|---|---|---|
| | = 6.25 | mm |
| Criterion for spacing of normal links | | |
| Min. Longitudinal Bar dia X 16 | = 400 | mm |
| Min. dimension of column | = 230 | mm |
| Max. 300 mm | = 300 | mm |
| Provided spacing | = 225 | mm |

**Table For Links**

| | Required | | | Provided | |
|---|---|---|---|---|---|
| | **Normal Design** | **Shear Design** | **Ductile Design** | **Normal Zone** | **Ductile Zone** |
| Link Dia. | 8 | --- | --- | 8 | --- |
| Spacing | 225 | --- | --- | 225 | --- |

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| | | | |
|---|---|---|---|
| PILE CAP DESIGN Design Code | : | IS 456 + IS 13920 - 2016 | |
| Pilecap No | : | PC4 | |
| Column No | : | C13 | (300mm X 600mm) |
| GRID. No | : | 73/H | |
| | | | |
| Concrete Grade | : | M25 | |
| Steel Grade | : | Fe500 | |
| Clear Cover | : | 50 | mm |
| Top of pile-cap below ground | : | 3.4 | m |
| | | | |
| Density of Soil | = | 18 | kN/cum |
| Founding Depth | = | 0.8 | m |
| Pile Capacity in Compression | = | 600 | kN |
| Pile Capacity in Tension | = | 270 | kN |
| Pile Capacity in Shear | = | 20 | kN |
| Pile Capacity Reduction | = | 0 | % |
| Pile Overloading | = | 10 | % |
| Pile Group Overloading | = | 10 | % |
| Pile Capacity Increase for EQ | = | 25 | % |
| Pile Capacity Increase for Wind | = | 25 | % |
| Live Load Reduction | = | 0 | % |
| | | | |
| Consider Capacity Design | : | No | |
| Consider Overburden Pressure | : | No | |
| | | | |
| No. of Piles | = | 5 | |
| Pile Diameter | = | 450 | mm |
| Pilecap Offset | = | 150 | mm |
| Pile Spacing | = | 2.5 | x Ø |
| Pilecap Size | = | 1670 | mm (edge) |
| Pilecap Depth | = | 600 | mm |
| Pile-cap Wt. | = | 71.966 | kN |

**Check for Maximum Load on One Pile:**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | : | 114 | |
| Critical Load Combination | : | [14] : (LOAD 3: DL) +0.8 (LOAD 4: LL) +0.24 (LOAD 1: RSX) +0.8 (LOAD 2: RSZ) | |
| Pcomb | = | 1335.4 | kN |
| Ptotal | = | Pcomb + Pilecap Wt. | |
| | = | 1407.37 | kN |
| Mx | = | 93.41 | kNm |

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| | | | |
|---|---|---|---|
| My | = | 11.76 | kNm |
| P | = | Ptotal/ No. of Piles | |
| | = | 281.47 | kN |
| Pmx | = | 31.586 | kN |
| Pmy | = | 2.889 | kN |
| | | | |
| Maximum load on pile | = | 315.95 | kN |
| Allowable load on pile | = | 600 x 1.25 | |
| | = | 750 | kN |

**Check for Maximum Load on Pile Group:**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | : | 101 | |
| Critical Load Combination | : | [1] : (LOAD 3: DL) +(LOAD 4: LL) | |
| Pcomb | = | 1317.68 | kN |
| Ptotal | = | Pcomb + Pilecap Wt. | |
| | = | 1389.65 | kN |
| Mx | = | 4.16 | kNm |
| My | = | 2.18 | kNm |
| | | | |
| Maximum load on pile group | = | 1389.64 | kN |
| Allowable load on pile group | = | 5 x 600 + 0.4 x 600 | |
| | = | 3240 | kN |

**Check for Maximum shear on Pile Group:**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | : | 106 | |
| Critical Load Combination | : | [6] : (LOAD 3: DL) +0.3 (LOAD 1: RSX) +(LOAD 2: RSZ) | |
| Pcomb | = | 1214.65 | kN |
| Ptotal | = | Pcomb + Pilecap Wt. | |
| | = | 1286.62 | kN |
| Mx | = | 115.14 | kNm |
| My | = | 13.98 | kNm |
| Vx | = | -8.8 | kNm |
| Vy | = | 110.78 | kNm |
| Maximum shear on pile group | = | $\text{sqrt}(-8.8^2 + 110.78^2)$ | |
| | = | 111.13 | kN |
| Shear capacity of pile group | = | 5 x 20 x 1 x 1.25 | |
| | = | 125 | kN |

**Check for Uplift Load on Pile:**

No uplift in any pile

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**Design for Bending:**

**Bottom Reinforcement Along Parallel Edge**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | : | 201 | |
| Critical Load Combination | : | [60] : 1.5 (LOAD 3: DL) +1.5 (LOAD 4: LL) | |
| Pcomb | = | 1976.52 | kN |
| Ptotal | = | Pcomb + Pilecap Wt. | |
| | = | 2084.468 | kN |
| Mx | = | 6.24 | kNm |
| My | = | 3.28 | kNm |
| Ppile | = | Max Load on pile | |
| | = | 417.39 | kN |
| | | | |
| Deff | = | 520 | mm |
| Beff | = | 750 | mm |
| DfCol | = | 0.76 | m |
| BMux | = | Ppile X DfCol | |
| | = | 317.28 | kNm |
| PtReq | = | 0.47 | % |
| AstReq (BM) | = | 2445 | sqmm/m |
| AstPrv | = | T20 @ 125 C/C | |
| | = | 2513.28 | sqmm/m |

**Top Reinforcement Along Parallel Edge**

| | | | |
|---|---|---|---|
| D | = | 600 | mm |
| | <= | 1000 | mm, Hence |
| AstReq (BM) | = | Min Pt for Top Reinforcement X D X 1000 | |
| | = | 0.06% X 600 X 1000 | |
| | = | 360 | sqmm/m |
| AstPrv | = | T12 @ 125 C/C | |
| | = | 365.3 | sqmm/m |

**Bottom Reinforcement Along Perpendicular Edge**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | : | 408 | |
| Critical Load Combination | : | [76] : 1.5 (LOAD 3: DL) -0.45 (LOAD 1: RSX) -1.5 (LOAD 2: RSZ) | |
| Pcomb | = | 1630.32 | kN |
| Ptotal | = | Pcomb + Pilecap Wt. | |
| | = | 1738.268 | kN |
| Mx | = | -162.56 | kNm |
| My | = | -15.11 | kNm |
| Ppile | = | Max Load on pile | |
| | = | 415.6 | kN |

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| | | | |
|---|---|---|---|
| Deff | = | 540 | mm |
| Beff | = | 750 | mm |
| DfCol | = | 0.66 | m |
| BMuy | = | Ppile X DfCol | |
| | = | 273.04 | kNm |
| PtReq | = | 0.37 | % |
| AstReq (BM) | = | 1990 | sqmm/m |
| AstPrv | = | T16 @ 100 C/C | |
| | = | 2010.6 | sqmm/m |

**Top Reinforcement Along Perpendicular Edge**

| | | | |
|---|---|---|---|
| D | = | 600 | mm |
| | <= | 1000 | mm, Hence |
| AstReq (BM) | = | Min Pt for Top Reinforcement X D X 1000 | |
| | = | 0.06% X 600 X 1000 | |
| | = | 360 | sqmm/m |
| AstPrv | = | T10 @ 215 C/C | |
| | = | 365.3 | sqmm/m |

**Design for One Way Shear:**

**Along Parallel Edge**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | : | 201 | |
| Critical Load Combination | : | [60] : 1.5 (LOAD 3: DL) +1.5 (LOAD 4: LL) | |
| Pcomb | = | 1976.52 | kN |
| Ptotal | = | Pcomb + Pilecap Wt. | |
| | = | 2084.47 | kN |
| Mx | = | 6.24 | kNm |
| My | = | 3.28 | kNm |
| Ppile | = | Max Load on pile | |
| | = | 419.8076 | kN |

Location of critical section is at d/2 from face of column

| | | | |
|---|---|---|---|
| Section Location from column center | = | 410 | mm |

Data for Piles

| Pile No | Load (kN) | % covered | Shear (kN) |
|---|---|---|---|
| P1 | 414.29 | 0 | 0 |
| P2 | 414.79 | 100 | 414.79 |
| P3 | 417.39 | 100 | 417.39 |
| P4 | 418.2 | 16.11 | 350.82 |
| P5 | 419.81 | 16.11 | 352.17 |

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| | | | |
|---|---|---|---|
| Design Shear Force (Vu) | = | Max. of (Shear due to P2+P4, P3+P5) | |
| | = | 769.56 | kN |
| Deff | = | 520 | mm |
| Beff | = | 2271.84 | mm |
| Tv | = | Vu/(Beff x Deff) | |
| | = | 0.65 | N/sqmm |
| Tc | = | 0.48 | N/sqmm |
| Av | = | 500.14 | mm |
| Shear enhancement factor | = | 2 X Deff / Av | |
| | = | 2.08 | |
| Enhanced shear strength (Tce) | = | 0.99 | N/sqmm |
| Tv | < | Tce, Hence Shear Reinforcement is not required | |

**Along Perpendicular Edge**

| | | |
|---|---|---|
| Critical Analysis Load Combination | : | 405 |
| Critical Load Combination | : | [73] : 1.5 (LOAD 3: DL) +0.45 (LOAD 1: RSX) +1.5 (LOAD 2: RSZ) |
| Pcomb | = | 1821.97 kN |
| Ptotal | = | Pcomb + Pilecap Wt. |
| | = | 1929.92 kN |
| Mx | = | 172.71 kNm |
| My | = | 20.97 kNm |
| Ppile | = | Max Load on pile |
| | = | 449.538 kN |

Location of critical section is at d/2 from face of column

| | | | |
|---|---|---|---|
| Section Location from column center | = | 570 | mm |

Data for Piles

| Pile No | Load (kN) | % covered | Shear (kN) |
|---|---|---|---|
| P1 | 313.79 | 100 | 313.79 |
| P2 | 355.34 | 0 | 0 |
| P3 | 372.01 | 0 | 0 |
| P4 | 439.24 | 4.62 | 418.95 |
| P5 | 449.54 | 4.62 | 428.77 |

| | | | |
|---|---|---|---|
| Design Shear Force (Vu) | = | Max. of (Shear due to P1+P2+P3, P4+P5) | |
| | = | 847.72 | kN |
| Deff | = | 540 | mm |
| Beff | = | 2046.3 | mm |
| Tv | = | Vu/(Beff x Deff) | |
| | = | 0.77 | N/sqmm |
| Tc | = | 0.39 | N/sqmm |

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| | | | |
|---|---|---|---|
| Av | = | 204.21 | mm |
| Shear enhancement factor | = | 2 X Deff / Av | |
| | = | 5.29 | |
| Enhanced shear strength (Tce) | = | 2.04 | N/sqmm |
| Tv | < | Tce, Hence Shear Reinforcement is not required | |

**Design of Face Reinforcement:**

| | | | |
|---|---|---|---|
| AsfrReq | = | SFR % X D X Beffsfr | |
| | = | 0.05 X 600 X 500 / 100 | |
| | = | 150 | sqmm |
| Asfr Prv | = | 2-T10 | |
| | = | 157 | sqmm |

**Check for Load Transfer from Column to PileCap**

| | | | |
|---|---|---|---|
| Critical Analysis Load Combination | = | 201 | |
| Critical Load Combination | : | [60] : 1.5 (LOAD 3: DL) +1.5 (LOAD 4: LL) | |
| P | = | 1976.52 | kN |
| A2 | = | 0.18 | sqm |
| A1 | = | 4.8 | sqm |
| Base Area | = | 4.8 | sqm |
| A1 | < | Base Area | |
| Modification Factor | = | SquareRoot(A1/A2) < = 2 | |
| SquareRoot(A1/A2) | = | 5.16 | |
| Thus, Modification Factor | = | 2 | |
| Concrete Bearing Capacity | = | 0.45 X Fck X Modication Factor X Column Area | |
| | = | 4050 | kN |
| Concrete Bearing Capacity | > | P, Hence Safe. | |

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